RESEARCH ON REDUCTION OF SOUND PRESSURE LEVELS OF UNDERWATER SOUND FROM OFFSHORE WIND TURBINES BY SEAGRASS COMMUNITY

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Many fishermen are anxious about the harmful influence on fisheries due to underwater sound from offshore wind turbines. Consequently, for reducing underwater sound by construction of seagrass beds, and the absorption of underwater sound with frequencies, which an offshore wind turbine generates, was investigated in the *Zostera marina* (seagrass) dominant community, on the coast of Aomori Prefecture, Japan. As a result, it was considered that densely growing *Zostera marina* community could reduce the sound pressure levels of underwater sound when the height from sea bottom is ca 50 cm and the biomass is more than 15.2 kg in wet weight or 4 kg in dry weight.

Keywords: offshore wind farm, reduction of underwtater sound, fhishery, seagrass bed, *Zostera marina*

INTRODUCTION

On the coasts of Japan, fishery cooperative associations are granted for common fishery rights by the Governors in the range of several miles from seashore excluding some parts, such as port areas. In many cases, without the consent of fishermen offshore wind turbines cannot be introduced. Some fishermen are interested in promoting fishery by utilizing offshore wind farm projects, but many fishermen are anxious about the harmful influence on the fisheries due to underwater sound from offshore wind turbines.

On the other hand, since seaweed/seagrass communities support marine ecosystems, some prefectural governments have constructed seaweed/seagrass beds for the purpose of increasing fishery production. If the construction of seaweed/seagrass beds could reduce the underwater sound from offshore wind turbines fishermen might be more likely to accept offshore wind farms.

However, there was no research on reduction of underwater sound from offshore wind turbines by the construction of seaweed/seagrass beds. Therefore, the absorption of four characteristic frequency sound of offshore wind turbines by seagrass was investigated in a *Zostera marina* (Monocots, Alismatales) dominant community.

MATERIAL AND METHODS

The investigation was carried out at the depth of 3 m of a *Zostera marina*dominant community in Ishizaki fishing port, Sotogahama, Aomori Prefecture, Japan on August 2017 (Figure 1). The underwater speaker (Fostex US300) and underwater microphone (Aquasound AQH-020) were installed at a distance of 3 m (Figure 2), and at the depths of 0.5 m, 1.5 m and 2.5 m to measure the sound pressure levels (dB re 1 μPa).

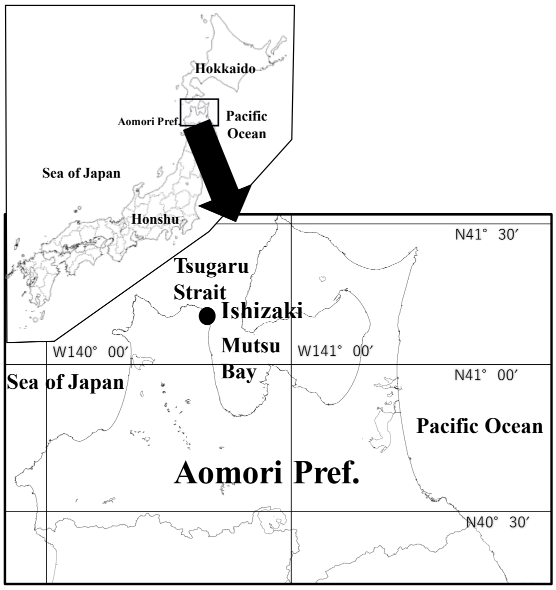

Figure 1. Maps showing the investigation site (●).

Subsequently, the sound pressure levels at each depth was measured while collecting every quadrat (1 m × 1 m) of seaweed/seagrass grown between the microphone and the speaker in a range of 1 m in width and 3 m in length (Figure 2). The sound with frequencies of 28 Hz, 56 Hz, 84 Hz and 112 Hz, which the offshore wind turbine generates[1], was emitted from the underwater speaker for 5 minutes, during each measurement. The sensitivity of underwater microphone was from -194.4 to -190.0 dB re 1 V μPa^{-1} at 20 Hz – 200 Hz. Biomass (wet weight and dry weight ,dried in oven at 110°C for 11 hours), number of individuals/shoots and length of blade/plant on the collected seaweed/seagrass from each quadrat were measured.

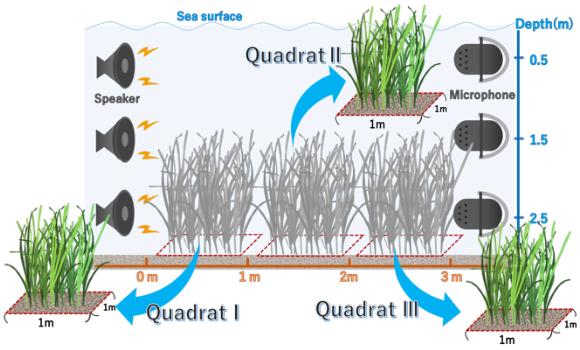

Figure 2. Measurement procedure of underwater sound and biomass.

RESULTS AND DISCUSSION

Biomass and density of benthos collected from each quadrat is shown in Table 1. *Zostera marina, Saccharina japonica* (Phaeophyceae, Laminariales) and periphyton *Obelia* sp. were collected from the sea bottom between the underwater microphone and speaker. *Zostera marina* accounted for 98.7% of the total biomass and dominated. The bottom sediment was sandy and flat.

Table 1. Biomass (wet-g/m^{-2}) and density (individuals/shoots m^{-2}) of benthos in the quadrats between the microphone and speaker. Numbers in paraentheses show biomass of dry weight.

Species	Quadrat I (near the speaker)		Quadrat II		Quadrat III (near the microphone)		Average	
	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density
Plantae								
Monocots								
Alismatales								
Zostera marina	6,017(1,597)	230	4,208(1,101)	253	4,939(1,268)	312	5,055(1,322)	265
Heterokontophyta								
Phaeophyceae								
Laminariales								
Saccharina japonica			1.2(1.5)	1	179.3(23.8)	13	60.2(7.9)	4.7
Animalia								
Hydrozoa								
Leptomedusae								
***Obelia* sp.**	3.2	-	3.5	-	6.0	-	4.2	-

Figure 3. Community of *Zostera marina* at the investigation site.

Zostera marina growing densely was observed at the investigation site and covered about a height of 50 cm on the sea bottom (Figure. 3). Its biomasses in wet weight and dry weight were in the range from 4,208 g m^{-2} to 6,017 g m^{-2} and from 1,101 to 1,597, respectively (Table 1). The percentages of dry weight to wet weight was in the range from 25.7 to 26.5. Its shoots density was in the range from 230 m^{-2} to 312 m^{-2}. Neither flowering shoots nor fruiting shoots were observed. Its plant length was in range from 22 cm to 192 cm and the mean value was 117.0 cm (Figure. 4). The range of 120cm to 140cm marked the greatest value of data arranged in order of frequency.

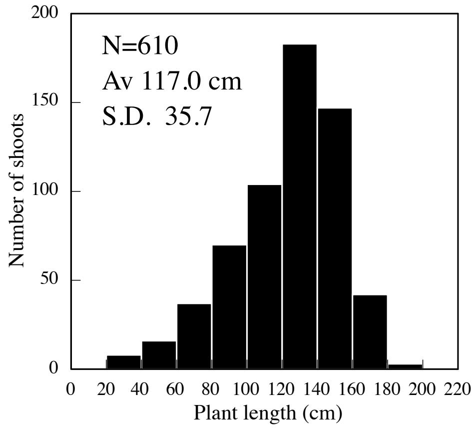

Figure 4. Frequency of plant length of *Zostera marina* collected from the quadrats

Relationship between the setting depth of the underwater microphone and speaker, and sound pressure levels was shown in Figure 5. The underwater sound with a frequency of 28 Hz could not be picked up through the investigation. The underwater sound pressure levels with frequencies of 56 Hz, 84 Hz and 112 Hz were 102.4 dB, 117.1 dB and 133.9 dB at the depth of 0.5 m, and 99.3 dB, 114.7 dB and 132.0 dB at the depth of 1.5 m, respectively. At the depth of 2.5 m, the underwater sound with a frequency of 56 Hz could not be picked up, but the sound pressure levels of the underwater sound with frequencies of 84 Hz and 112 Hz were 96.4 dB and 115.8 dB, respectively.

Relationship between the biomass of *Zostera marina* and sound pressure levels at the depth of 1.5 m and 2.5 m is shown in Figure 6. *Zostera marina* accounted for about 99% of the total biomass, so the biomass of *Zostera marina* could be regarded as a whole biomass of the investigation site.

At the depth of 1.5 m, the underwater sound pressure levels with frequencies of 56 Hz, 84 Hz and 112 Hz were in the range of 98.5 - 99.3 dB, 112.5 - 114.7 dB and 130.9 - 132.0 dB, respectively. At the depth of 2.5 m, the sound pressure levels shown similar values to these of the depth of 1.5 m in the range of biomass from 0 kg to 9.1 kg in wet weight or from 0 kg to 2.7 kg in dry weight, respectively. There was no significant difference on sound pressure levels depending on the biomass of *Zostera marina*.

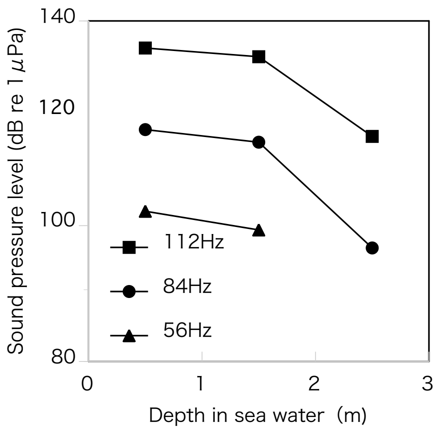

Figure 5. Relationship between the setting depth of the sound instruments and sound pressure levels

However, when the biomass was 15.2 kg in wet weight or 4.0 kg in dry weight, sounds with the frequency of 56 Hz could not be picked up, and the sound pressure levels of 84 Hz and 112 Hz were reduced by 19.2 dB and 17.2 dB from 96.4 dB and 115.8 dB, respectively.

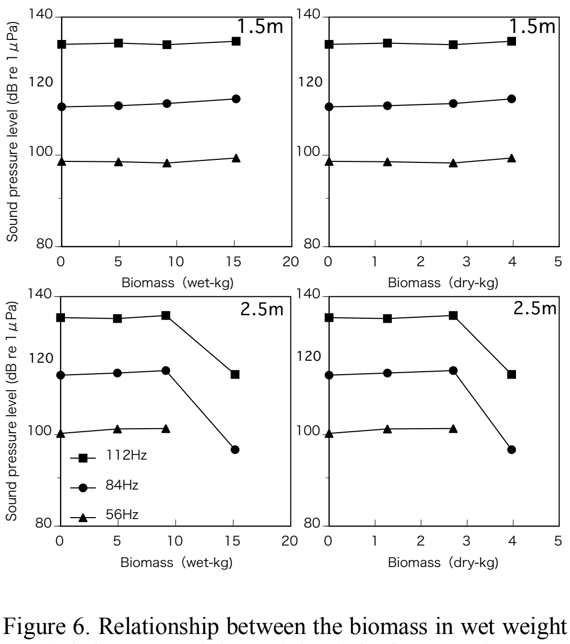

Figure 6. Relationship between the biomass in wet weight (left figures) and dry weight (right figures) of *Zostera marina* and sound pressure levels at the depth of 1.5 m (upper figures) and 2.5 m (lower figures).

As the results of this investigation, it was considered that the densely growing *Zostera marina* community could reduce the underwater sound with frequencies, which the offshore wind turbine generates, when the height from the sea bottom is less than 50 cm and the biomass is more than 15 kg in wet weight or 4 kg in dry weight. In addition, the results suggested that the reducing effect on the underwater sound from the offshore wind turbine generators limited to the depth range where seaweed/seagrass densely grows.

The fixed bottom type offshore wind powers have been installed at the depths from 4 m to 14 m along the coast of Japan[2]. Furthermore, there are offshore wind projects planned at deeper depths in Japan. In order to reduce the underwater sound at a higher point from the sea bottom with such a depth of water, dense communities of seaweed/seagrass species which algal/plant length develope extraordinarily long are required. Thallus of brawn algae such as *Sargassum horneri* (Phaeophyceae, Fucales) and *Saccharina* species (Phaeophyceae, Laminariales) are relatively common species around northern coast of Japan and often reaching several meters high[3, 4]. Meanwhile, *Zostera caulescens* (Monocots, Alismatales) develop its vegetative shoots up to several meters and its flower shoot reaches 7.8 m high which is the world's tallest record in all seagrasses and forms communities in northern Japan[5]. In the future, a similar investigation will be carried out in the communities of these species on the coast of Aomri Prefecture.

The questionnaire survey on opinions about offshore wind farms in fihsermen of Aomori Prefecture clarified that "Underwater sound at power generation" was the second most frequently opposed reason by the respondents who answered "Unacceptable" to offshore wind farms (Kirihara, submitted). Meanwhile in Japan, seaweed and seagrass communities and ecosystems for fisheries production have been specially called "MOBA", and it has been preserved, restored, and developed by the public works of country and local government [6]. These "MOBA (seaweed/seagrass beds)" are generally constructed in the sandy or muddy seabottom by setting stones or concrete blocks as a growth substrates of seaweeds or by transplanting seeds or vegetative shoots of seagrass[7, 8].

There is a possibility that constructing "MOBA (seaweed/seaweed beds)" contribute to both fishermens' anxiety reduction to offshore wind farms and increase fishery production.

ACKNOWLEDGEMENT

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